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LENGTH OF SERVICE OF PARTS IN THE KD-35-MATI DIESEL TRACTOR ENGINE

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/Note: Tables referred to herein are appended./

KD-35-MATI 37-hp Diesel engines have been installed in the Kirovets D-35 caterpillar tractors. This engine incorporates the latest improvements in engine design and is distinguished by dependability and durability. In operational tests, one of the new engines operated under load for about 2,000 hours, including more than 1,900 hours on a tractor under field conditions. The basic parts of this engine, including the connecting-rod-crankshaft assembly were not dismantled during the tests.

Engine power after warm-up was 37.3 hp with a fuel consumption of 222 grams per horsepower-hour. After 2,000 operating hours, engine power increased to 38 hp with approximately the same fuel consumption. Thus, despite the long period of time it was in operation without undergoing repairs, the engine continued to be in good operating condition. Wear on the piston rings scarcely showed up at all in the consumption of lubricating oil; the average amount of oil consumed was less than 3 percent of the Diesel fuel consumed. Even at the end of the test the amount of oil consumed was no more than the maximum allowed.

The following paragraphs present data on the wear on the basic parts after 2,000 operating hours and preliminary estimates of the length of their useful lives and the nature of the repair operations required.

The greatest amount that removable interchangeable cylinder sleeves can wear is 0.36-0.41 millimeter. After the first 1,000 hours, the wear on these sleeves was 0.23-0.25 millimeter. Thus the wear was faster at the beginning. This is explained by the change in the elasticity of the piston rings, which were not replaced during the test.

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The section of maximum sleeve wear is in the plane perpendicular to the axis of the crankshaft opposite the first compression ring when the ring is in top dead-center position. This section occupies less than 5 millimeters along the line generating the cylinder. The wear rapidly decreases with increased distance from the upper edge of the sleeve, and at a distance of 15 millimeters from the area of most wear there is only about one fourth as much wear.

The amount the sleeves in the most worn area are out-of-round is equal to half the amount of wear.

The sleeves of the first experimental engines were not subjected to the heat-treatment provided for by the technical specifications; therefore, they wore out several times faster than standard serially produced sleeves.

For cylinders of these dimensions, the maximum wear necessitating change of sleeve is estimated to be 0.6 millimeter. This is quite a safe limit, since the area of maximum wear is small, and only the top compression ring operates along it It is obvious from the above data that the length of service of sleeves which have not been heat-treated is considerably longer than 2,000 hours.

It can be estimated that cylinder sleeves manufactured in accordance with the accepted technical specifications will have to be changed after approximately 3,000-3,500 hours' use.

The pistons have four compression rings and two oil-control rings. The upper oil-control ring is directly under the compression rings; the second oil ring is on the lower part of the piston.

The top compression ring and the oil-control rings wear the fastest. After 2,000 hours, the gap in the top ring lock spread to 6-6.5 millimeters, while the gap in the oil-control ring locks increased to 4-5 millimeters. The gap in the second compression ring lock spread 2-2.6 millimeters.

Only in the top compression ring is widthwise wear observed--about 0.07 millimeter. The second compression ring does not wear uniformly, varying from 0.01 to 0.06 millimeter. The bottom rings show almost no wear widthwise.

This data shows that after 2,000 hours, the upper compression and oil-control rings must be changed. Although the other compression rings can be used somewhat longer, it is of doubtful expedience not to change all the rings when making repairs, since, after assembly of the engines, there is not the safe tightness obtained by using unchanged rings with a worn-out sleeve, in which circumstance rings on their second working cycle wear at a slower rate than new rings because the old rings are less elastic. Therefore (pending a more complete study of the matter), it is recommended that all the piston rings be changed at the same time.

In order to dismantle the connecting-rod-crankshaft assembly when changing piston rings, it is necessary to remove the cylinder head and drop the pan. The pistons are taken out from the head side. To avoid damaging the lands between the piston ring grooves when taking out the pistons, it is necessary to first round off the ridges which have appeared on the upper part of the sleeves as a result of wear on the sleeves by the top piston rings.

The engine has aluminum pistons. The parts of the piston that undergo wear are the skirt guide surface, the openings in the bosses under the piston pin, and the grooves for the piston rings. The wear on the guide surface is not uniform along the line generating it, and after 2,000 hours of operation the wear is about 0.1 millimeter along the edges and about 0.05 millimeter in the middle part. After the same period, the openings under the piston pin are worn 0.02 millimeter; in some cases the wear amounts to 0.04 millimeter. The ring grooves other than the top ones are worn 0.01-0.03 millimeter widthwise; the top grooves are worn 0.06-0.07 millimeter.

It can be estimated that the period of service of the piston will be the same as that of the sleeves, 3,000-3,500 hours. After that amount of time, the skirt guide surface will be worn down approximately 0.2 millimeter and the clearance between this part of the piston and the sleeve will be about 0.6 millimeter. By this time, the opening under the piston pin and the top groove of the piston will have worn the maximum allowable amount. Tightening the sleeve will reduce the widthwise wear on the top piston groove.

The piston pins are worn uniformly both in the places joining the bushing of the top end of the connecting rod and in the bosses of the piston. The wear is from 0.01 to 0.03 millimeter, in which ovalness and taper are practically nonexistent. The bushings of the top ends of the connecting rods are worn 0.02-0.03 millimeter in the planes of the connecting rods; in a perpendicular direction the bushings scarcely change size at all.

After the engine had operated 2,000 hours, the clearance between the piston pin and the bushing of the top end of the connecting rod was less than 0.06 millimeter. With this much clearance, there is no need to make repairs or replace parts. Even if the rate of wear increases later on because of the increased clearance, these parts can be used about 1,000 hours more. The crankshaft runs in five main bearings, which have interchangeable bushings of lead bronze. The connecting-rod bearings also have interchangeable bushings of lead bronze.

The wear on the journals after 2,000 hours is 0.07-0.08 millimeter. The journals are worn quite uniformly, with the exception of the first and third, which are somewhat less worn. The journals are less than 0.03 millimeter out-of-round. The lower main bushings are more worn than the upper; the wear on them with respect to thickness is 0.04 millimeter, while the wear on the upper bushings is only 0.02 millimeter.

The maximum wear on the crankpins is 0.10-0.13 millimeter. Unequal wear of the crankpins with respect to circumferences is observed. In the majority of crankpins the out-of-round is almost equal to the maximum wear. The upper bushings are worn 0.03-0.04 millimeter with respect to thickness and the lower bushings are worn 0.04-0.05 millimeter.

Annular cuts resulting from the abrasive action of particles which have fallen into the lubricating oil are observed on all the journals and crankpins of the crankshaft after 2,000 hours.

The clearance in the connecting-rod bearings of the new engines is from 0.06 to 0.10 millimeter. After 2,000 hours, the clearance has increased 0.2 millimeter and is more than 0.25 millimeter. The clearance in the most worn main bearings has increased 0.15 millimeter and amount to 0.20-0.25 millimeter. The wear on individual crankshaft bearings is given in Table 1.

In determining the maximum allowable clearance in bearings, it is necessary to consider not only what clearance is necessary for sufficient lubrication of the friction surface, but also the need to maintain correct seating of bushings. Abnormally large clearance results in wear on the seating under the bushings. When such damage has taken place it is necessary to bore under the bushings which have increased in outside diameter. This presents serious difficulties. The damaged connecting-rods have to be changed, since it is not expedient to bore the lower ends of the rods and use oversize connecting-rod bushings.

50X1-HUM

In view of the standards adopted for engines of other makes, it may be assumed that when there is such wear the connecting-rod bearing pins of the shaft ought to be ground and that the clearance spaces in the main bearings are close to the limit. Therefore, the period of service before repair of the crankshaft and bearings is roughly 2,000 hours.

The camshaft runs in three bronze bushings. After the engine has run for 2,000 hours, there is not much wear on the cams and the shaft. The camshaft bushings wear uniformly, 0.04-0.05 millimeter. The clearance between the camshaft and the bushings has increased from 0.08 millimeter to 0.12-0.13 millimeter, but this permits further use without repair.

The valve tappets and their seats in the block do not wear much either. After the engine had run for 2,000 hours, the outside diameters of the tappets proved to be within the limit permitted for new parts. The ports in the block wore less than 0.02-0.03 millimeter.

The inlet and exhaust valves are relieved of side pull by special valve guides, which assure correct seating of the valves and small amounts of wear on them. The inlet valve stems were worn 0.01-0.02 millimeter, and the exhaust valve stems, 0.02-0.04 millimeter. The most wear on the valve-stem-guide bushings, 0.06-0.08 millimeter, is observed in their lower part. The wear on the bushings of individual inlet valves is 0.12-0.14 millimeter. These bushings are more worn because of abrasive rubbing of stems coated with carbon.

The engine worked for 2,000 hours without the valves' being reseated. During this period, ring-shaped wear and cavities appeared on the bearing surfaces.

The valve-stem guides did not show any noticeable wear with respect to either outside diameter or face. The openings in the supports of the rocker arms were worn 0.02-0.04 millimeter. The wear on the rocker rollers was less than 0.01 millimeter, while the bushings wore 0.02-0.03 millimeter.

The camshaft parts can be used for considerably more than 2,000 hours without repair. After this period the only operations required are grinding of the valve heads, adjustment of the valve seats, and subsequent reseating of the valves.

The other engine parts are also sufficiently long-wearing and can be used without repair for more than 2,000 hours. An exception to this is the fan ball bearings, the radial clearance of which was 0.13 and 0.19 millimeters with an axial clearance of about 0.5 millimeter. In view of the severe conditions to which these bearings were subject and the possible accidents if they burn out, badly worn bearings should be changed after 2,000 hours' use.

The long-wearing qualities of these engines create favorable conditions for their repair. From a technical standpoint, reconditioning cylinder sleeves is possible; however, since this would mean that oversize pistons and rings also would be required, and since, in addition, the organization of the serial processing of worn-out parts is extremely difficult in comparison with the manufacture of new sleeves, it is of doubtful expedience to recondition sleeves. This subject should receive special study.

We might also consider the excessive use of oversize rings and piston pins. The use of the latter may be recommended in exceptional cases when individual pistons or the bushings of the top ends of the connecting rods are accidentally excessively worn.

Repair-size parts will be much used in the reconditioning of crankshaft bearings. Reconditioning bearings involves regrinding journals and installing repair-size bushings. To correct the shaft, it is necessary to make the journals less than 0.5 millimeter smaller in diameter. Crankshafts are very durable and their journals may be ground eight or ten times. After this, bearings may be safely used only if the same skill is used in their repair as in the manufacture of new engines. Therefore, it is advisable to organize the production of repair bushings whose manufacture is complex in enterprises manufacturing standard bushings.

The grinding of crankshafts must be carried on in special repair plants. The diameters of journals are made accurate to 0.02 millimeter, the allowable out-of-round and taper is 0.01 millimeter. Special care must be taken to keep the main journals in alignment. They may sag no more than 0.02 millimeter. They must be ground with a sufficient degree of accuracy. Therefore, the grinding machines in repair plants must be kept in good condition.

Engines being repaired must be carefully and correctly reassembled. This is particularly important in regard to crankshaft bearings.

An important prerequisite for improving the quality of assembly work is the preparation space and the presence of the necessary measuring instruments, attachments, and assembly tools, including dynamometric switches. The parts must be cleansed with compressed air and special washing shops must be set up in repair plants.

Table 1

Bearing No	Journals			Bearings	Max Clearance (mm)
	Out-of-round (mm)	Taper (mm)	Wear (mm)	Wear (mm)	
1	0.03	0.01	0.04	0.02	0.16
2	0.03	0.04	0.07	0.04	0.21
3	0.02	0.01	0.05	0.06	0.21
4	0.01	0.01	0.08	0.07	0.25
5	0.03	0.03	0.07	0.03	0.20

Table 2

Bearing No	Crankpins			Bearings	Max Clearance (mm)
	Out-of-round (mm)	Taper (mm)	Wear (mm)	Wear (mm)	
1	0.09	0.02	0.10	0.08	0.26
2	0.[illegible]	0.02	0.11	0.08	0.27
3	0.1[illegible]	0.04	0.12	0.08	0.28
4	0.08	0.04	0.13	0.07	0.28

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